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GB 2286749 A GB 2281008 A GB 2271486 A
GB 2260050 A WO 94/11956 A1 US 5218367 A
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(58) Field of Search
UK CL (Edition O) H4L LDSG LDSL LDSX
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ON-LINE : WPI

(54) Steering an antenna in accordance with mobile location

(57) The position of a mobile station 21-23 is determined by propagation times of signals or attenuation of signals received from a number of base stations 14-16 and controls the steering of an antenna 18 to maximise radiated power in the direction of the mobile 21. The system may control operation so that mobile stations in a similar location use the same timeslot for communication.

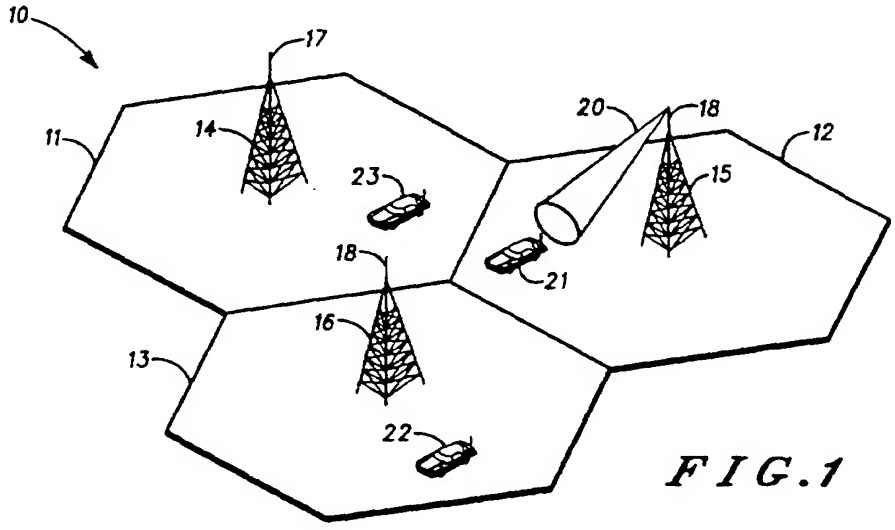

FIG.1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

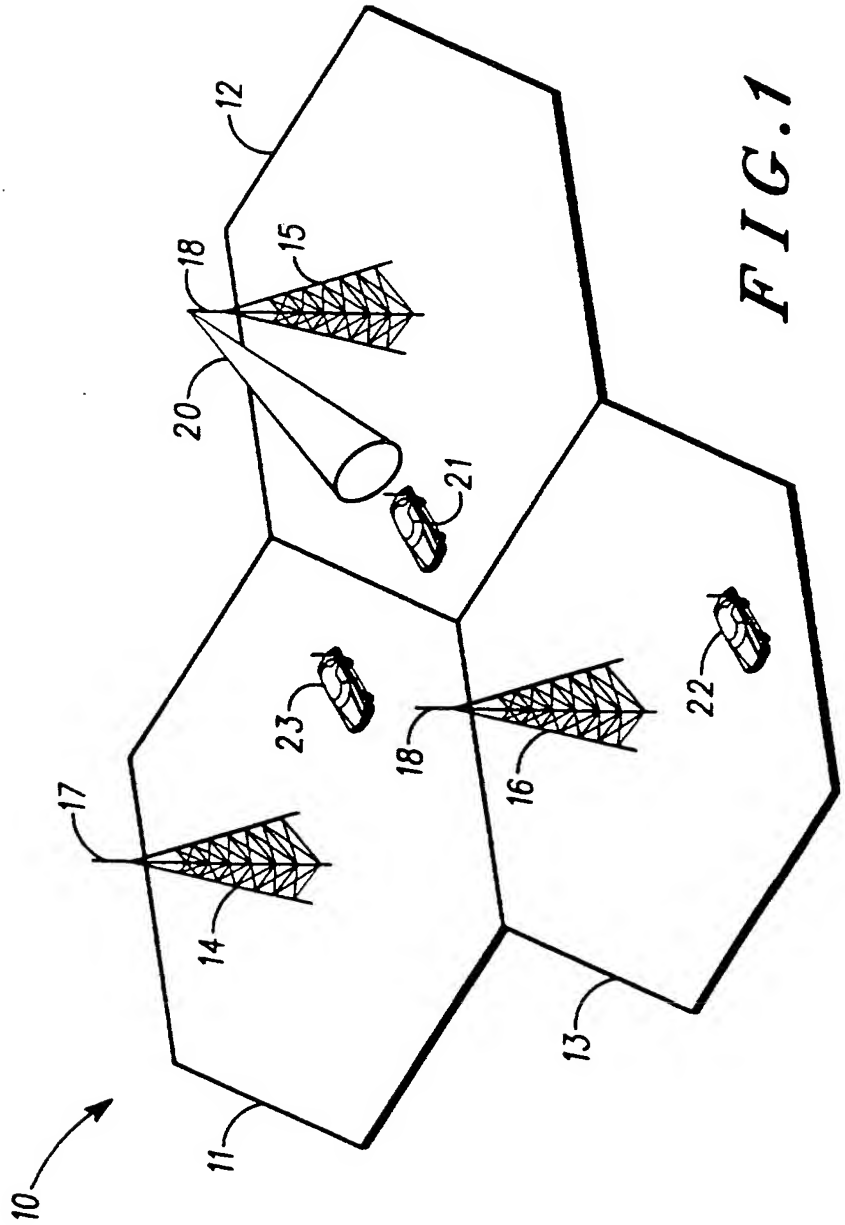

FIG.1

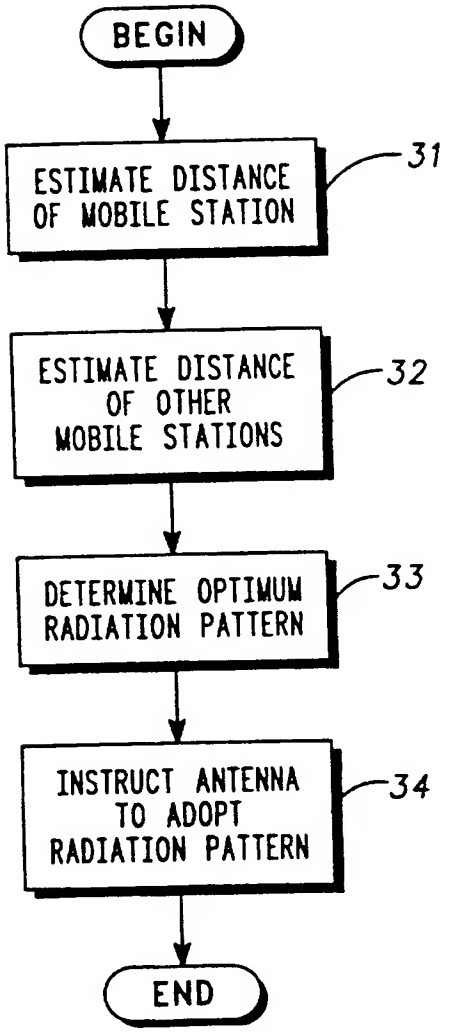
BEGIN
ESTIMATE DISTANCE OF MOBILE STATION
31
ESTIMATE DISTANCE OF OTHER MOBILE STATIONS
32
DETERMINE OPTIMUM RADIATION PATTERN
33
INSTRUCT ANTENNA TO ADOPT RADIATION PATTERN
34
END

FIG. 2

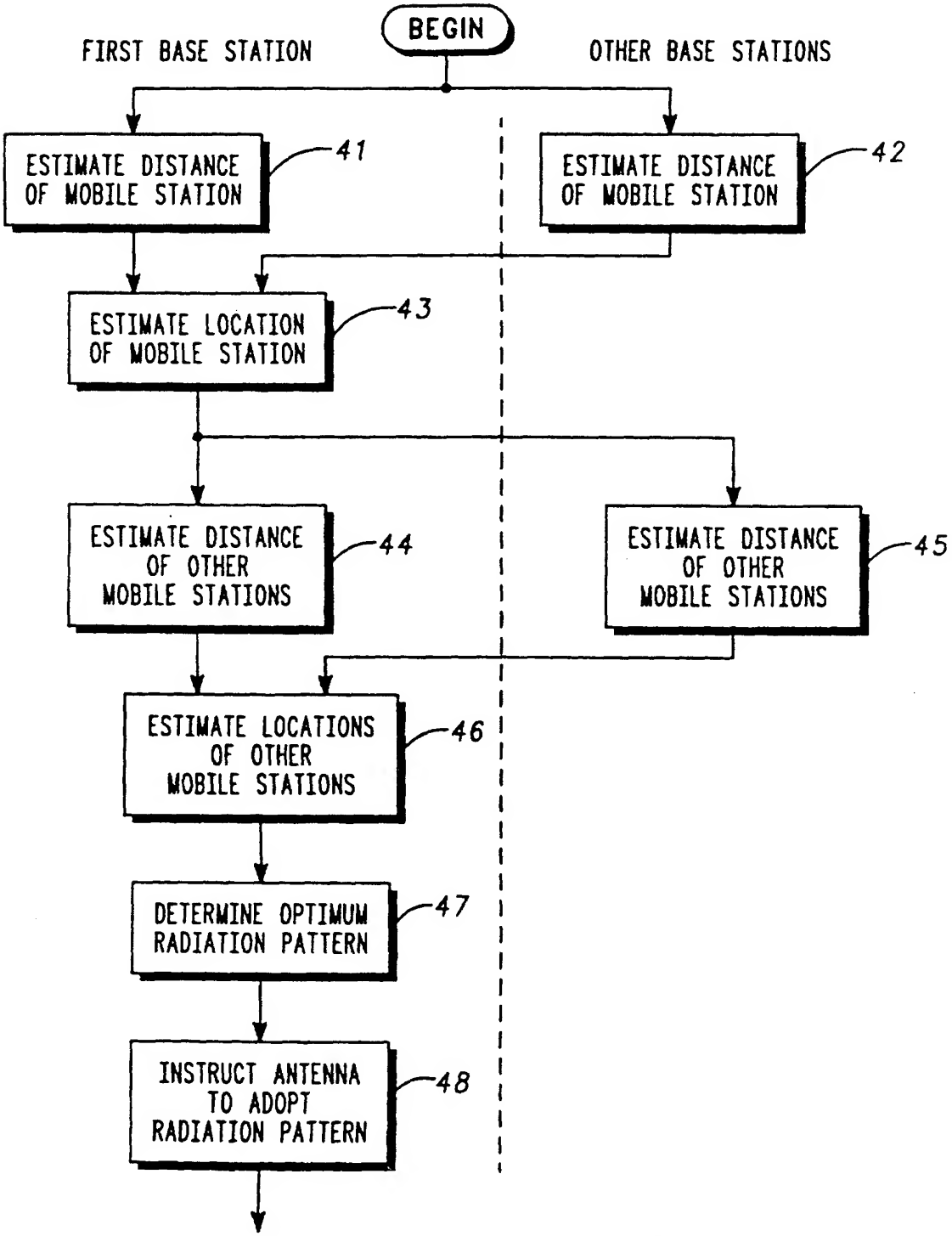
BEGIN
FIRST BASE STATION
OTHER BASE STATIONS
ESTIMATE DISTANCE OF MOBILE STATION
41
ESTIMATE DISTANCE OF MOBILE STATION
42
ESTIMATE LOCATION OF MOBILE STATION
43
ESTIMATE DISTANCE OF OTHER MOBILE STATIONS
44
ESTIMATE DISTANCE OF OTHER MOBILE STATIONS
45
ESTIMATE LOCATIONS OF OTHER MOBILE STATIONS
46
DETERMINE OPTIMUM RADIATION PATTERN
47
INSTRUCT ANTENNA TO ADOPT RADIATION PATTERN
48

FIG. 3

METHOD FOR A STEERABLE ANTENNA

Field of the Invention

This invention relates in general to an apparatus and method for steering an antenna, and more particularly to an apparatus and a method for steering an antenna in a communications system according to a location of a mobile station.

Background to the Invention

Present communications systems, such as cellular radio systems divide an area over which communications service is to be offered into a number of smaller areas, called cells, each of which is served from a single base site. Often, the area to be served from a single base station site is divided into smaller areas, called sectors. The system determines which base station site, and which sector, is to be used for communication with a particular mobile station by making measurements on the signal received from the mobile (including its strength) at a number of fixed locations.

Each area to be served has a separate antenna at the base station site for transmitting to the mobile station. A signal is also received from the mobile station at the base station site using either a single antenna or more than one antenna (the latter being called diversity reception). Depending on circumstances, some or all of the antennas at the base station site may be used for both transmission and reception.

In a radio communication system employing time division multiple access (TDMA), transmission on a single RF carrier from a base station is divided into a number of time slots, each of which is dedicated to transmission to a particular mobile station according to a predetermined sequence. Similarly, each mobile transmits to the base station sequentially in a series of time slots. Some means of synchronisation between the base and mobile stations is required to ensure that each mobile station only transmits in its correct time slot.

The characteristics of the antennas used at the base station site are often a compromise between maximising coverage of the desired area, and

minimising interfering signals transmitted to, and received from, other areas.

The technique of phased array antennas is well known to those skilled in the art. A phased array antenna consists of a number of radiating elements. Each element is connected to a common port by a circuit which divides the power from the transmitter to individual elements in the antenna in pre-determined proportions, and with pre-determined relative phases of voltage (as measured at the input to the radiating elements). If the power division ratio or the relative phase to the individual elements is changed, the characteristics of the aerial will be changed (in particular, the polar distribution of radiated power from the antenna, also know as the radiation pattern). By this means the radiation pattern of the antenna may be steered in a particular direction.

The steerable antenna may be adjusted to maximise the radiated power in the direction of a mobile station from which a signal is being received. The angle of arrival of the signal from the mobile station is calculated from measurements made on the signal received by a number of adjacent antennas or radiating elements of the same antenna at the base station. The directional properties of an antenna are the same for the transmission and reception of signals (the term radiation pattern is therefore used throughout this document to describe the directional properties when both transmitting and receiving).

The steerable antenna may therefore also be used to maximise the signal received from a given direction. In the case of a steerable antenna used for reception, it is possible to use the same antenna for receiving the signal as is used for making measurements. It is also possible to change the radiation pattern of the antenna to minimise it in a particular direction.

In a cellular radio system, measurements of the level of signal received from a mobile station at a number of base sites is used to assist the system in determining which of the cells should be used to communicate with that mobile. They can also be used to estimate the distance between the base and mobile stations, but these estimates are poor because the signal level also depends on other unknown factors, including the terrain and local obstructions to the radio signal.

In many radio systems that use digital communications between the base site and mobile stations, it is possible to measure the propagation

delay of the radio path between them, and from this calculate the length of the radio path. The direct distance between transmitter and receiver must (subject to any measurement uncertainty) be less than or equal to the length of the radio path. In a cellular radio employing TDMA, the measurement of delay may be performed as part of the process of synchronisation between base and mobile stations.

In the GSM system of digital cellular radio, the measurement of propagation delay between a base station and a mobile station with which it is communicating, which occurs as part of the synchronisation between them, is known as timing advance (in this document, references to the GSM system include the DCS1800 system).

However, getting one distance measurement approximating the distance between the base site and the mobile station does not give a location of the mobile station and therefore may not be reliable to depend on for directing a steerable antenna. What is desired are reliable measurements that determine a location of the mobile station in order to steer the antenna efficiently towards the mobile station and minimise radiation in other directions.

Summary of the Invention

According to the present invention, a method is provided for steering an antenna in a communications system having a mobile station and at least one base station, including the steps of determining the location of the mobile station and changing the radiation pattern of the antenna according to the location of the mobile station.

In an alternative embodiment, a base station is provided having a steerable antenna for use in a communications system including means for determining the location of a mobile station and means for changing the radiation pattern of the antenna dependent upon the location of the mobile station.

Brief Description of the Drawing

FIG. 1 shows a diagram of a cellular radiocommunication system incorporating base stations and an antennas according to the present invention.

FIG. 2 is a flow chart for a method for steering an antenna according to an embodiment of the present invention in which the distance of the mobile station from one base station is estimated.

FIG. 3 is a flow chart for a method for steering an antenna according to an embodiment of the present invention in which the distance of the mobile station from a plurality of base stations is estimated.

Detailed Description of the Preferred Embodiment

Referring to FIG. 1, there is shown a diagram of a cellular radiocommunication system 10 in which the area to be served is divided into cells 11-13. In each cell there is a base station 14-16, each of which has at least one antenna 17-19. The base station may have a single antenna for both transmission and reception or separate antennas for transmission and reception. It may have more than one antenna for diversity reception. These antennas have directivity, that is, if the base station is used for transmitting, a higher RF field 20 will be radiated in certain directions than in others. It will of course be appreciated that if the same antenna is used for reception, the received power will be higher for the same RF field incident on the antenna from certain directions than for the same RF field incident from other directions. The directivity of an antenna can be expressed as a gain, that is the ratio of the RF field radiated in a particular direction from the antenna to the field that would be radiated by a reference antenna.

If a particular base station station 15 is in communication with a mobile station 21, then the base station is able to estimate the distance of the mobile station from the base station. One means of estimating this distance is for the base station to calculate the attenuation of the radio path between the base station and mobile station and to compare this with a propagation model of the attenuation of a typical radio path against distance.

A second, and generally more accurate, means of estimating the distance of mobile station from a base station is to measure the propagation delay of radio signals between the base station and mobile station. The equivalent distance may be calculated using the known velocity of propagation of radio waves. In the GSM system of digital cellular radio, the measurement of propagation delay between the base station and the

mobile station with which it is communicating occurs as part of the synchronisation between them, and is known as timing advance.

Referring to FIG 2, the first step in this method 31 is for the base station to estimate the distance of a particular mobile station 21 from the base station 15. A second step 32 may optionally be to estimate the distance of other mobile stations 22, 23 from the base station. In the third step 33, the base station determines the optimum radiation pattern 20 from the antenna of the base station 18. This may be to either maximise the radiated field in the direction of the particular mobile station 21, or to minimise it in some other direction, such as the direction of other mobile stations 22, 23. For instance, if the distance of a particular mobile station 21 from the base station with which it is in communication 15 is small, and the base station antenna 18 is elevated relative to the mobile station 21, the radiation pattern of the RF field 20 from the antenna 18 may be altered in a vertical plane so that the field radiated in a horizontal direction is reduced. Thus, the interference caused by the base station 15 to another mobile station 22 using the same frequency in a different cell 13, at a greater distance from the base station 15 would be reduced. In the fourth step 34, the base station 15 instructs its antenna 18 to adopt this radiation pattern while it is in communication with the mobile station. Similarly a vertical radiation direction may be changed to change a radiation pattern. Propagation delay measurements and/or attenuation measurements between the mobile and at least one base station may be used to determine the location of the mobile station. An independent positioning system may also be used to determine the location of the mobile station.

As will be appreciated, the directivity of a receive antenna at the base station can be altered in a like manner to maximise the received signal from a particular mobile station, or to reduce the level of interference from another mobile station.

Referring to FIG 3, the method of the present invention includes estimating the radial distance of a mobile station from measurements taken from at least two base stations. The location of the mobile station within the cell 12 may then be estimated from such measurements. The first step 41 is for a first base station to estimate the distance of a particular mobile station 21 from the base station 15. Concurrently 42, at least one further base station 16 also estimates the distance of the particular mobile station 21 from that base station 16. The second step 43 is for the base

station 15 to use the estimate of the distance of the mobile station 16 from the base station 15, together with the estimate(s) of the distance of the mobile station 16 from the further base station(s) 16 and the known location of each of the base stations, to estimate the location of the mobile station. In the third step 44, 45, 46, the location of other mobile stations 22, 23 operating in other cells 11, 13 may optionally also be estimated in a like manner, using estimates of the distance of the mobile station from two or more base stations. In the fourth step 47 the base station determines the optimum radiation pattern 20 from the antenna of the base station 18. This may be to either maximise the radiated field (gain) in the direction of the particular mobile station 21, or to minimise it in some other direction, such as the direction of other mobile stations 22, 23. The radiation pattern can then be altered in the horizontal, as well as vertical, planes so that the radiation pattern of the RF field 20 from the antenna 18 can be maximised in the direction of the mobile station 21, and/or can be reduced in the direction of at least one other mobile station 22, 23. In the fifth step 48, the base station 15 instructs its antenna 18 to adopt this radiation pattern while it is in communication with the mobile station.

In a radio communication system employing time division multiple access (TDMA), the radiation pattern can be changed for each separate timeslot. If such a system employs more than one RF carrier in a cell, it is possible for the system to control the operation of the mobile stations such that those mobile stations in a similar location use the same timeslot for communication. Thus, the radiation pattern(s) of the base station antenna(s) required for effective operation of the invention will be appropriate for all of the mobile stations using one timeslot.

In an alternative embodiment, the mobile station estimates its position using an alternative means, and reports its estimated position to the base station.

Claims

1. A method of steering an antenna in a communications system having a mobile station and at least one base station, the method comprising the steps of:

determining the location of the mobile station; and

changing the radiation pattern of the antenna according to the location of the mobile station.

2. The method of claim 1 wherein the step of determining the location of the mobile station includes estimating a radial distance of the mobile station from the base station.

3. The method of any of the preceding claims wherein the step of determining the location of the mobile station includes estimating radial distances from at least two base stations.

4. The method of any of the preceding claims wherein the step of changing the radiation pattern of the antenna includes changing a horizontal radiation direction of the antenna.

5. The method of any of the preceding claims wherein the step of changing the radiation pattern of the antenna includes changing a vertical radiation direction of the antenna.

6. The method of any of the preceding claims wherein the step of determining the location of the mobile station includes measuring a propagation delay between the mobile station and at least one base station.

7. The method of any of the preceding claims wherein the step of determining the location of the mobile station includes measuring the attenuation of the radio path between the mobile station and at least one base station.

8. The method of any of the preceding claims wherein the step of determining the location of the mobile station includes estimating the location of the mobile station by an independent positioning system.

9. The method of any of the preceding claims wherein the step of changing the radiation pattern of the antenna includes increasing a gain of the antenna in the direction of the mobile station and reducing a gain of the antenna in another direction.

10. The method of any of the preceding claims wherein the communications system is a time division multiple access digital communications system.

11. The method of claim 6 wherein the communications system is a GSM communications system and the step of measuring a propagation delay includes using a timing advance parameter of the communications system.

12. A base station having a steerable antenna for use in a communications system including at least one base station for receiving and transmitting communications signals to at least one mobile station, the base station comprising:

means for determining the location of the mobile station; and

means for changing the radiation pattern of the antenna dependent upon the location of the mobile station.

13. The method or aparatus of any of the preceding claims wherein the antenna is a tranmitter antenna.

4. A steerable antenna substantially as herein described with reference to FIG. 1 of the drawing.

5. A method for steering an antenna substantially herein described with reference to FIGs. 2and 3 of the drawing.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9522860.7
Relevant Technical Fields (i) UK Cl (Ed.O) H4L (LDSL, LDSG, LDSX) (ii) Int Cl (Ed.6) H04Q (7/36, 7/38)	Search Examiner P S DERRY Date of completion of Search 16 JANUARY 1996
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ON-LINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-13

Categories of documents

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Y:	Document indicating lack of inventive step if combined with one or more other documents of the same category.	E:	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A:	Document indicating technological background and/or state of the art.	&:	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y	GB 2286749 A	(NORTHERN TELECOM) see whole document	1, 4, 9
Y	GB 2281008 A	(NORTHERN TELECOM) see especially page 2, lines 9-11	1, 5
X, Y	GB 2271486 A	(MOTOROLA) see especially page 15, lines 11-30	X: 1, 8, 10, 12, 13 Y: 1-7, 11
Y	GB 2260090 A	(NEC) see whole document	2-3, 6, 10-12
Y	WO 94/11956 A1	(SOUTHWESTERN BELL) see especially the Abstract	1, 4
Y	US 5218367	(SHEFFER) see especially the Abstract	7
X, Y	JAPIO Abstract Accession No AX 89-275502 & JP 1202036 (TOSHIBA) see Abstract		X: 1, 12 Y: 1-11, 13

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